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[P1.058] Treating ground water contaminated with high perchlorate concentrations by an ion exchange membrane bioreactor

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Perchlorate (ClO_4^-) contamination of drinking water has become a world-wide concern, especially where perchlorate contamination from military and aerospace industries threatens public water systems (Srinivasan and Sorial 2009). The main health concern regarding perchlorate is its interference with iodine uptake by the thyroid glands, affecting the normal development of fetuses, babies and young children (Urbansky and Schock 1999). Recently it was decided by the US EPA to develop standard regulation for perchlorate contamination in drinking water (USEPA 2005). In the state of California such a standard already exists where the maximum perchlorate concentration for drinking water is 6 $\mu g\ L^{-1}$ (analytical detection limit) (CDPH 2011). High ClO_4^- concentration was found in Israel's coastal aquifer in the Ramat Ha'Sharon area (Adar and Nativ 2005), and appears to be present in the ground water as well as in the vadose zone. In the center of the contaminated plume the ClO_4^- concentration is as high as 250ppm(Gal, Ronen et al. 2008). Authorities are now proposing the pump-and- treat approach to prevent the contamination by perchlorate of hundreds of millions m^3 of adjacent groundwater.

The ion exchange membrane bio-reactor (IEMB) developed by J. Crespo's group in Portugal (Crespo and Reisent 2001), integrates an anion exchange membrane for the removal of perchlorate by Donnan Dialysis from the contaminated water feed, and a bioreactor for biologically reducing the perchlorate into chloride using ethanol as the electron/carbon donor. The anion exchange membrane used in the process (ACS Neosepta, Tokuyama Soda) is selective for mono-valent anions such as nitrate and perchlorate. This innovative technology takes the advantage for the complete reduction of perchlorate while keeping the treated water separated from the bio-compartment and therefore, avoiding the need for post treatment for the removal of bacteria and carbon source residuals. This process successfully reduced perchlorate concentration from 0.1 - 1 mg L^{-1} down to near detectable limits (Velizarov, Reis et al. 2002).

In the present study we examine the ability of the IEMB to treat ground water contaminated with high perchlorate concentrations of up to 250 ppm. A series of experiments using synthetic water simulating actual contaminated ground water from Ramat Ha'sharon Israel was conducted. The perchlorate flux across the anion exchange membrane was established through a mass balance analysis of both sides of the IEMB with and without bacteria in the bio-compartment. A correlation was found between the perchlorate flux and its concentration adjacent to the membrane, where, the higher the concentration, the greater the perchlorate flux. However, as perchlorate concentration increases beyond 10 ppm near the membrane, the flux strongly deviates from that predicted by Velizarov et al.(2000). Velizarov proposed a bi-ionic mechanistic model using Donnan exchange and diffusion equations, which presents a linear correlation between the perchlorate concentration and the flux. We have found that the perchlorate flux was considerably lower than the predicted flux of the model (Figure 1).

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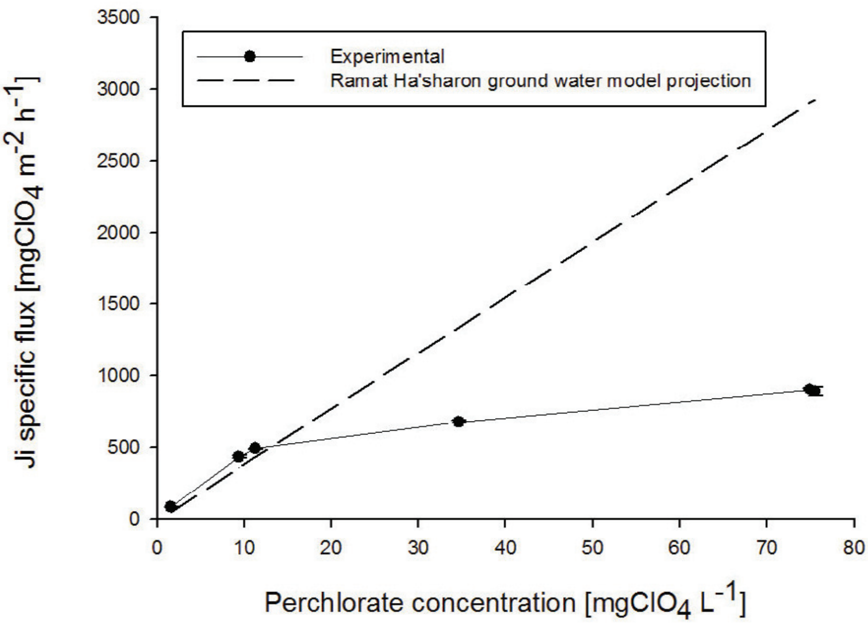

Figure 1: perchlorate donnan dialysis flux vs perchlorate concentration adjacent to the membrane for model (fractured line) and experimental results (circle).

Our results imply that an additional factor dictating the perchlorate flux through the ion exchange membrane has a significant contribution at high perchlorate concentrations. When testing the membrane's electric conductivity, it was found that membranes which were exposed to high concentrations of perchlorate did not retain their original conductivity after regeneration with high Cl^- concentrations. This is a clear indication for strong interactions of the perchlorate ions with the ACS Neosepta membrane, thus, hindering the perchlorate transport across the membrane. The Velizarov model is limited to low perchlorate concentrations where a significant effect of perchlorate on the membrane properties is not anticipated. On the other hand at higher concentrations studied here, the deviations from the model are clear and expected in light of these strong perchlorate ion-membrane interactions.

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